Section 1 -- Introduction

Importance of Fresh Water to Estuaries

The overwhelming influence of freshwater supply on (1) the composition, abundance and distribution of estuarine flora and fauna in space and time and (2) the physical, chemical, and biological processing of nutrients and other material in estuarine systems is well established (Schlacher and Wooldridge 1996; Nixon et al. 1996, Livingston et al. 1997, Brock, 2001). Modification of river discharge by diversion, withdrawal, channelization and damming has altered the timing and magnitude of the freshwater supply to estuaries (Whitfield and Wooldridge 1994; Hopkinson and Vallino 1995; Jassby et al 1995). In turn, these changes in delivery have had demonstrable impacts on estuarine receiving waters including decreased bio-diversity, loss of livable habitat, excessive stratification, hypoxia and eutrophication (Sklar and Browder, 1998; Estevez 2000a). As the human need for water increases, the amount of freshwater required by estuaries and other aquatic ecosystems has become an increasingly important issue for water managers (Postel et al. 1996). The challenge to management is how to allow human manipulation of freshwater while at the same time satisfying the needs of estuarine environments (Sklar and Browder 1998). A first step in meeting this challenge is to estimate estuarine requirements for freshwater.

Basis for Minimum Flows and Levels

The state of Florida requires the South Florida Water Management District (SFWMD) to develop Minimum Flows and Levels (MFLs) for priority water bodies within its jurisdiction. MFLs are developed pursuant to the requirements contained in Sections 373.042 and 373.0421 of Florida Statutes (F.S.). The minimum flow is defined as the ". . . limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area." The minimum level is defined as the ". . . limit at which further withdrawals would be significantly harmful to the water resources of the area." (Section 373.042(1), F.S.). Significant harm, as defined by the SFWMD in the Florida Administrative Code (F.A.C.) Section 40E-8.021(24), means the temporary loss of water resource functions, which result from a change in surface or ground water hydrology, that takes more than two years to recover, but which is considered less severe than serious harm. Technical supporting documentation, including scientific and technical data, methodologies, models and assumptions, is developed for each water body and subject to scientific peer review (Chapter 373.042(4), F.S.). The specific water resource functions addressed by a MFL and the duration of the recovery period associated with significant harm are established by rule (Chapter 40E-8 F.A.C.) for each priority water body.

MFLs are to be established based on the best available information. Protection of non-consumptive uses may be considered and provided for in the establishment of MFLs (Section 373.042, F.S.). A baseline condition for the protected resource functions must be identified through consideration of changes and structural alterations in the hydrologic system (Section 373.042(1), F.S.). If it is determined that water flows or levels will fall below an established MFL within the next 20 years or that water flows or levels are presently below the MFL, the water management district must develop and implement a recovery or prevention strategy (Section 373.0421(2), F.S.).

The District Water Management Plan (DWMP) for South Florida (SFWMD, 2000a) includes a schedule for establishing MFLs for priority water bodies within the South Florida Water Management District (SFWMD). Section 373.042(2), F.S. requires each water management district to develop a MFL Priority Water Body List that includes the name of the water body and the date (year) in which the MFL will be established. The SFWMD is further required to annually update this list and schedule, make any necessary revisions, and submit the revised list to FDEP for review and comment.

MFLs for the Caloosahatchee River and Estuary

Development of Initial MFL Criteria

The Caloosahatchee River and Estuary (**Figure 1-1**) were first placed on the MFL Priority List in 1999. The District compiled results of previous and ongoing studies, initiated additional research, analyzed and interpreted data necessary to develop “technical criteria” for the Caloosahatchee River and Estuary, to determine low water conditions (water levels and/or flows) that may cause significant harm to water resources. The resource that was at greatest risk for impact was identified as an existing 640-acre bed of aquatic vegetation, *Vallisneria americana*, located downstream of the S-79 water

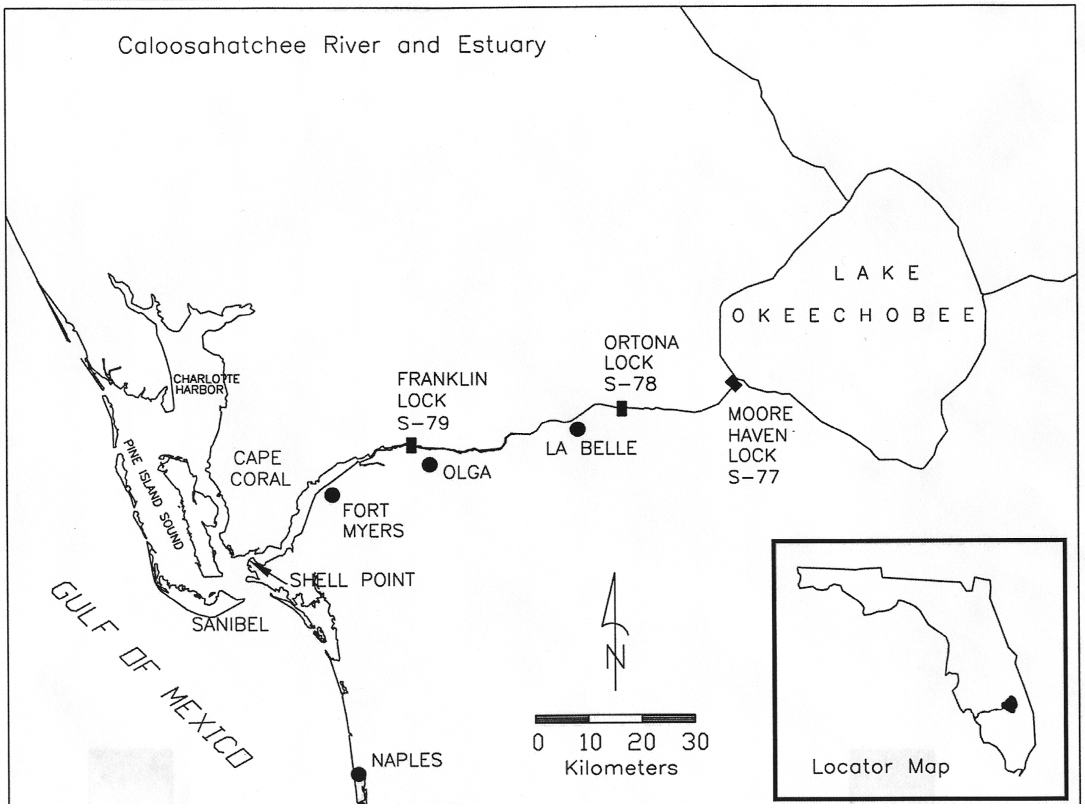

Figure 1-1. Map of the Caloosahatchee River and Estuary showing water control structures and major urban areas.

control structure. The MFL criteria consist of a minimum water flow rate, a duration of time that flows can fall below this rate before damage occurs, and a return frequency (how often such conditions can occur over a specified time period). Based on research conducted in the field and related laboratory studies, it was determined that the *Vallisneria americana* plant community would be adversely impacted if salinity exceeded 10 ppt for a period greater than 30 days. In order for full recovery to occur, such events should not occur during two consecutive years. Statistical analysis of historical flow and salinity data indicated that a flow of 300 cfs was needed through the S-79 structure to prevent salinity at the vegetation bed from exceeding 10 ppt. The proposed technical criteria were then subjected to scientific peer review. The original document was completed in July 2000 and received independent scientific peer review pursuant to Section 373.042, F.S.

Once the proposed technical criteria were approved by the Governing Board, rule development and rule making processes, including public workshops and opportunities for administrative challenge, were initiated. The rule defines the resources that are at risk and the water levels or flows necessary to protect these resources from significant harm. The MFL was not considered to be "established" until the final rule was approved and adopted. Rule development workshops were held in August and December 2000 and in January 2001 to discuss concepts proposed for the Caloosahatchee River and estuary. The final rule, which was adopted by the SFWMD in September 2001 and later incorporated into Chapter 40.E.8. F.A.C.

Other Resource Protection Tools

The proposed MFL's are not a "stand alone" resource protection tool; but must be considered in conjunction with all other resource protection responsibilities granted to the water management districts by law. These include regulatory components such as consumptive use permitting, water shortage management, and water reservations; construction and maintenance of structural components to improve water storage and conveyance capabilities; and the development and implementation of operational protocols to ensure that water is effectively distributed to meet regional needs.

Recovery and Prevention Strategy

The MFL study indicated that the proposed criteria will be exceeded on a regular and continuing basis until additional storage is provided in the basin to supply the additional water needed. Therefore the MFL document also included a recovery and prevention strategy. The structural and operational features of the recovery plan will be implemented through ongoing SFWMD water supply development efforts, including development of regional water supply plans and the Comprehensive Everglades Restoration Plan (CERP). The SFWMD has completed a Lower West Coast Regional Water Supply Plan (SFWMD, 2000a) and a Caloosahatchee Water Management Plan (SFWMD 2000b), pursuant to Chapter 373.0361, F.S., which include projects that are needed to implement the MFL recovery and prevention strategy. The CERP, which addresses water supply needs throughout South Florida as components of the effort to restore the Everglades, includes features that will increase storage in the Caloosahatchee Basin through the construction of a reservoir and Aquifer Storage and Recovery wells (SFWMD and USACE 1999). Modeling studies using discharge scenarios that included CERP and

LECRWSP projects indicate that the MFL will be met by 2020 when these facilities in the Caloosahatchee basin are completed and fully operational.

The MFL Rule, in Section 40E-8.011(3) F.A.C., also states that the minimum flow criteria for the Caloosahatchee River and Estuary shall be reviewed and amended as necessary within one year of the effective date of the rule. The purpose of this review is to re-examine the technical and scientific basis of the Caloosahatchee MFL in light of comments by a scientific peer review committee and results obtained from additional field observations, laboratory experiments, and numerical model development. The review specifically evaluates the ability of the 300 cfs discharge at Structure S-79 to protect the 640-acre bed of *Vallisneria americana*. This report documents the methods and results of these studies, management implications, and additional investigations that are needed to further refine the recovery and prevention strategy.

History and Major Features of the Caloosahatchee River and Estuary

The Caloosahatchee River and Estuary are located on the southwest coast of Florida (**Figure 1-1**). The Caloosahatchee River runs from Lake Okeechobee to the Franklin Lock and Dam (S-79) where it empties into the estuary, which is some 40 kilometers long and terminates at Shell Point. The Caloosahatchee River is the major source of freshwater to the estuary. Enough water enters the estuary at S-79 to fill its volume over 8 times per year (Doering and Chamberlain 1999).

The hydrology of the Caloosahatchee system has been altered over time. The river has been permanently connected to Lake Okeechobee and about 20% of the water entering the estuary now comes from the Lake mainly as regulatory releases to maintain the Lake at a prescribed water level. The river has also been straightened and deepened and three water control structures have been added. The last, Structure S-79, was completed in 1966 to act, in part, as a salinity barrier (Flaig and Capece, 1998).

These changes have increased the variability in freshwater input and salinity in the estuary. During the wet season, rainfall runoff that was historically retained and/or evaporated within the watershed now reaches the estuary in greater volume and shorter time (USACE 1957). During the dry season, agricultural and urban water supply demands result in reduced flows to the estuary. The construction of S-79 truncated the estuary by blocking the natural gradient of freshwater/saltwater that historically extended into the upper reaches of the estuary during the dry season from November to May.

Long-term records of salinity at the head (S-79) and mouth (Shell Point) illustrate this high variability and truncation of the salinity gradient (**Figure 1-2**). During periods of low freshwater discharge (50 cfs or less), salt water regularly intrudes all the way to the structure, often resulting in salinities that exceed 10 parts per thousand (ppt or $^{o}/_{oo}$). The loss of fresh-brackish water habitat, that can be critical to the successful recruitment of many estuarine dependant species, has resulted in the loss of an important water resource function of the estuary during the dry season. By contrast, high rates of freshwater discharge (up to several thousand cfs) can cause salinity to drop below 5 $^{o}/_{oo}$ at the mouth of the estuary near Shell Point. The transition between the two states can be rapid, sometimes requiring less than a week. The fluctuations observed at the head and mouth of the estuary exceed the salinity tolerances of oligohaline and marine species.

The South Florida Water Management District recognized the need to identify a range of discharges from S-79 that will protect the system and began a research program in 1985 (Chamberlain and Doering 1998). In addition, the Florida Legislature has required that water management districts establish minimum flows and levels for priority water bodies within their jurisdiction and the SFWMD subsequently identified the need to establish a MFL for the Caloosahatchee River and Estuary by 2001.

Approach Used to Establish the Caloosahatchee MFL

The SFWMD began work in the mid 80s to collect simultaneous biota and water quality data, which was later expanded to include continuous salinity sensor monitoring, preliminary modeling, and lab + field experiments. These data were used to attempt to understand the correlation in space and time between biota and their stressors (primarily flow and salinity). This early work provided a basis to formulate the MFL.

Investigations by other researchers have validated this resource-based approach. The methods used by the SFWMD to establish MFL criteria for the Caloosahatchee River and Estuary are thus similar to the Valued Ecosystem Component (VEC) approach (USEPA, 1987) and the habitat overlap concept of Browder and Moore (1981). The VEC approach is the general name given to a method developed by the U.S. Environmental Protection

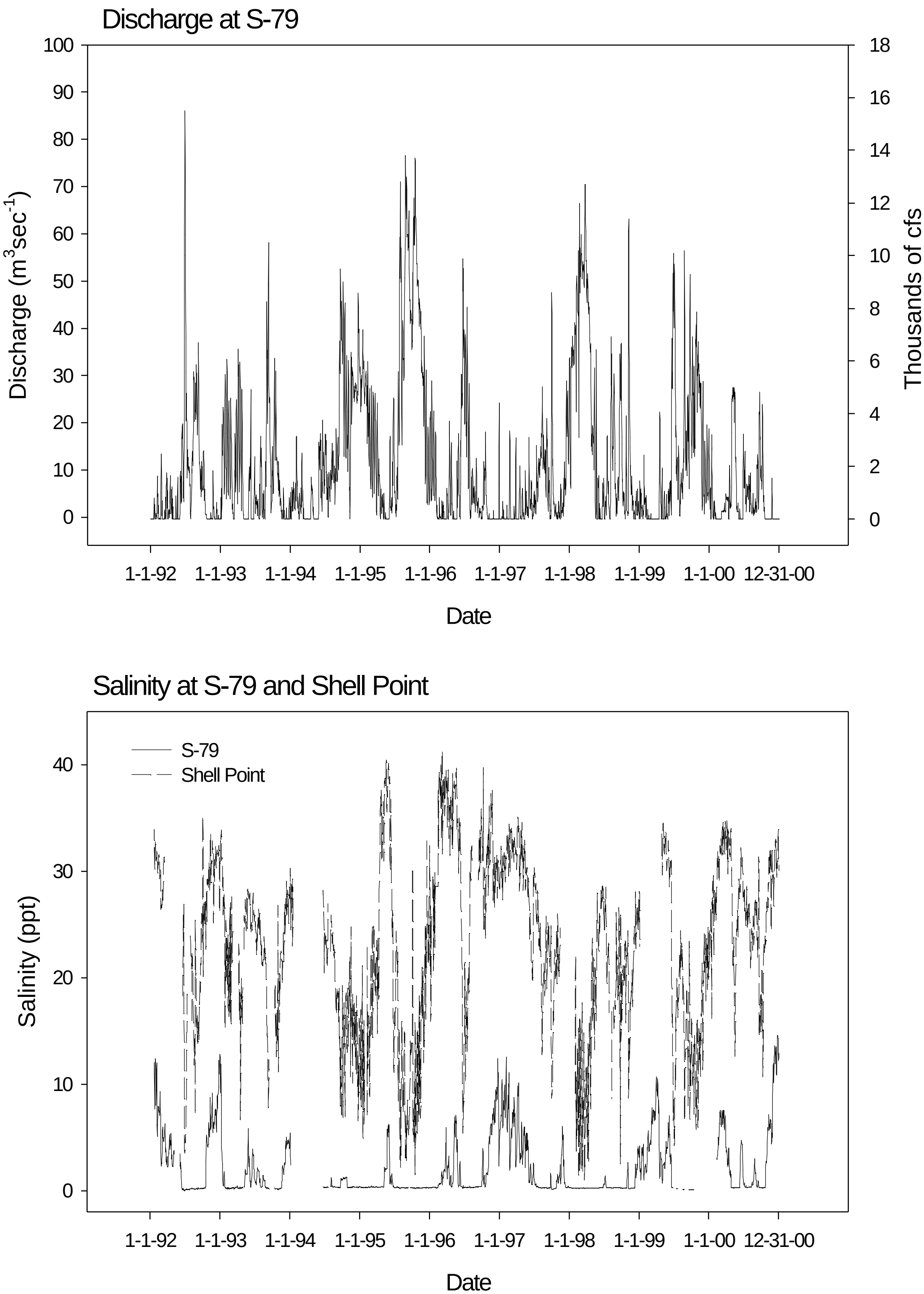

Figure 1-2. Daily freshwater discharge at Structure 79 (top panel) and corresponding daily average salinity at Structure 79 at the head of the estuary and at Shell Point near its mouth (bottom panel)

Agency (USEPA, 1987) to guide the monitoring programs within the National Estuary Program.

Definition of the Resource that Needs to be Protected

The approach has been modified to focus on providing critical estuarine habitat. In some cases that habitat might be physical, such as an open water oligohaline zone. In other cases the habitat is biological and typified by one or more prominent species (e.g. an oyster bar). For the Caloosahatchee, beds of submerged angiosperm grasses have been identified as a VEC. The salt tolerant freshwater species, *Vallisneria americana*, which occurs in the upper Caloosahatchee Estuary is the VEC for the minimum flow.

Vallisneria beds located in the upper Caloosahatchee Estuary represent an extremely important habitat found within the greater Charlotte Harbor estuarine system. When growing conditions are favorable, the most luxuriant beds are found in the 640 acre area between the Beautiful Island and the Ft. Myers bridge. This constitutes about 60% of the reported areal coverage of the species in the Caloosahatchee. *V. americana* grass beds have been documented as an important component of the upper and mid-estuary for more than 45 years (Phillips and Springer 1960; Gunter and Hall 1962).

Conditions Required for Resource Protection

As applied here the VEC approach assumes that (a) environmental conditions suitable for VEC will also be suitable for other species and (b) that enhancement of VEC will lead to enhancement of other species. Beds of submerged aquatic vegetation (SAV), like *Vallisneria americana*, are prominent species that are important to the ecology of shallow estuarine and marine environments. These beds provide habitat for many benthic and pelagic organisms, function as nurseries for juveniles and other early life stages, stabilize sediments, improve water quality and can form the basis of a detrital food web (Kemp et al. 1984; Thayer et al. 1984; Fonseca and Fisher 1986; Carter et al. 1988; Kilgore et al. 1989; Zieman and Zieman 1989; Lubbers et al. 1990; Virnstein and Morris 2000; Beck et al. 2001). Because of their importance, estuarine restoration initiatives often focus on SAV (Batiuk et al. 1992; Virnstein and Morris 2000; Johansson and Greening 2000). SAV are commonly monitored to gauge the health of estuarine systems (Tomasko et al.

1996) and their environmental requirements can form the basis for water quality goals (Dennison et al. 1993; Stevenson et al. 1993).

The concept of static and dynamic habitat overlap (Browder and Moore, 1981) is based on the ideas of Gunter (1961) that (a) estuaries serve a nursery function and (b) salinity determines the distribution of species within an estuary, and indeed different life stages of the same species. In addition, the concept recognizes the importance of the appropriate physical or static habitat to the nursery function and ability of the estuary to support diverse and abundant biotic populations. Freshwater inflow positions favorable salinities relative to important stationary habitat factors such as shoreline, water depth, and bottom type (Browder and Moore, 1981). In the present application, ecologically supportive freshwater inflows produce a temporal and spatial overlap between grass beds and physiologically tolerable salinity (**Figure 1-3).**

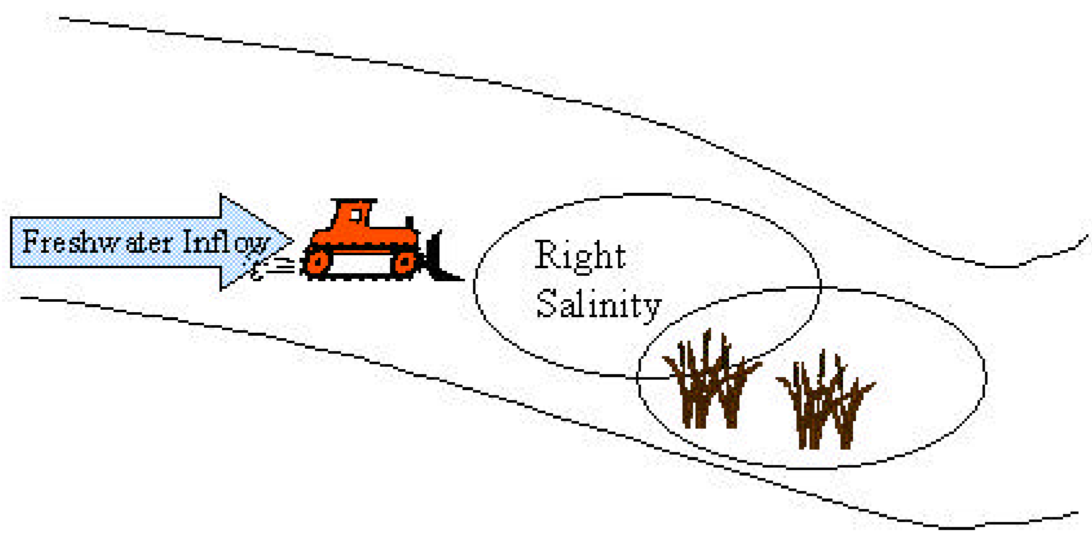

Figure 1-3. Habitat overlap concept. Freshwater inflow positions favorable salinity over grass beds in the upper Caloosahatchee Estuary

Since Browder and Moore (1981), more recent attempts to establish freshwater requirements are based on the concept of enhancing fisheries by providing appropriate spatial and temporal salinity structure. In the case of San Francisco Bay, the geographical position of the 2 ppt isohaline is correlated both with freshwater input and the abundance of striped bass (*Morone saxatilus*), starry flounder (*Platichthys stellatus*) and various components of their food web (Jassby et al. 1995). The relationships have been used in concert to indicate freshwater inflow requirements (Kimmerer and Schubel 1994; Jassby et al. 1995). In Texas, the overlap concept has been combined with a probabilistic approach (Sklar and Browder 1998). The salinity requirements of commercially important fish and shellfish are used to constrain possible inflow solutions that may, for example, maximize fisheries harvest (Longley 1994; Matsumodo et al. 1994; Powell and Matsumodo 1994). The requisite information for establishing a minimum flow is listed below.

1. Selection of an appropriate VEC
2. The distribution of VEC in the estuary
3. Physiological response of VEC over an environmentally representative range of salinities (magnitude and variability)
4. Relationship between freshwater inflow and the spatial distribution and temporal variability of salinity in the estuary
5. Salinity tolerance of the VEC
6. Definition of a degree of impact to VEC that constitutes "significant harm"
7. The spatial extent *<u>or condition</u>* of the VEC that requires protection by a minimum flow

An additional consideration that should be included in this analysis is the effect of flow on environmental factors other than salinity, such as sediment transport, overall water quality, light penetration and plankton dynamics. The first four requirements comprise the set of tools necessary to calculate the appropriate flow regime. The last three determine its actual magnitude. These tools allow us to answer the question: What magnitude of freshwater inflow will place the necessary salinity in a location in the estuary that will protect the resource from significant harm?

Review of the Caloosahatchee MFL Rule

MFL criteria were adopted and went into effect in September, 2001. The MFL was intended to maintain *Vallisneria* in a 640 acre area located between 24 and 30 kilometers upstream of Shell Point (**Figure 1-1**). The purpose of this review is to re-examine the technical and scientific basis of the Caloosahatchee MFL rule in light of comments by other agencies, the public and the scientific peer review panel and results obtained from additional field observations, laboratory experiments, and numerical model development.

As part of the development of the Caloosahatchee MFL, a scientific peer review of the technical criteria was conducted and a report produced (Edwards et al 2000). The review panel approved the general scientific approach used in establishing the MFL that has just been described. The panel also agreed that *V. americana* grass bed was an appropriate resource that needed to be protected and that the salinity criteria for protection of this resource were sufficient. The provision in the rule that exceedance of the salinity criteria for two consecutive years would cause significant harm was determined by the panel to be consistent with the SFWMD definition of significant harm, i.e. ". . . the temporary loss of water resource functions, which result from a change in surface or ground water hydrology, that takes more than two years to recover, but which is considered less severe than serious harm." (Section 40E-8.021(24), F.A.C.)

However, the peer review panel also identified specific scientific deficiencies in the technical documentation of the rule. Major criticisms of the initial effort were:

1. Lack of a hydrodynamic/salinity model
2. Lack of a numerical population model for *Vallisneria americana*
3. No quantification of the habitat value of *Vallisneria* beds
4. Effects of MFL flows on downstream estuarine biota

The SFWMD's existing research program (**Appendix A**) was expanded to address these concerns and included additional analysis of historical sampling efforts, field observations, laboratory experiments and development of modeling tools. This program is still in progress. The scope of this review is to:

1. Examine effects of low flows on other organisms in the Caloosahatchee, especially those located downstream in more marine areas. This analysis tests a basic assumption of the VEC approach: that flows or salinities appropriate for VEC are not detrimental to other important estuarine organisms. This part of the review relies on analyses of data from long-term monitoring of plankton and fish larvae and recently conducted ecological studies of American oysters.

2. Evaluate salinity and other criteria of the MFL Rule. The salinity tolerance of *Vallisneria americana* will be reviewed using additional field observations and results of new laboratory experiments conducted in the past year will be included. Other criteria will also be discussed.
3. Review the relationship between freshwater inflow and salinity in the Caloosahatchee Estuary based on (1) a mass balanced hydrodynamic model that is currently under development and (2) newly available estimates of freshwater inflows from the tidal basin downstream of S-79. This portion of the review will specifically look at the distribution of salinity in the estuary that results from a 300 cfs discharge at S-79.
4. Review the recovery strategy for the Caloosahatchee. The hydrodynamic model, currently under development, will be used to evaluate the effect of the CERP projects on the salinity distribution in the Caloosahatchee Estuary. In turn, a numerical population model of *Vallisneria americana*, also under development, will be used to determine whether these projects improve conditions for *V. americana*.

This review does not address the habitat value of *Vallisneria* beds. Habitat value is being determined through a 3-year contract (C-12836) with Mote Marine Lab that began in January 2002. The overall objective of the project is to identify which organisms use *Vallisneria* habitat in the Caloosahatchee River and how season, salinity and plant /bed morphometry affect habitat use.